जनसहभागितामा आधारित सौर्य सडक बत्ती कार्यक्रम संचालन कार्यविधि २०७२ को लागि

प्राविधिक स्पेसिफिकेशन

1. Background:

A standalone solar photovoltaic street lighting system is an outdoor lighting unit used for illuminating a street or an open area. Recent advances in LED lighting have brought very promising opportunities for application in street lighting. Combining LED's low power, high illumination characteristics with current photovoltaic (PV) technology, PV powered street light utilizing LED has become a norm in many places. In today's application, most of the common High Intensity Discharge (HID) lamps, often High Pressure Sodium (HPS) lamps are being replaced by more low powered Light Emitting Diode (LED) lamps.

A basic solar powered LED street light system components are:

1. Solar Panel or Photovoltaic Module
2. Lighting Fixture – LED lamp set
3. Rechargeable Deep Cycle Battery
4. Solar Charge Controller
5. Light Pole

The Solar Panel will provide electricity to charge the battery during day time. The battery's charging is controlled by a charge controller. The operation of the LED bulb is controlled by a control circuit either by using sensors such as Light Dependent Resistor (LDR) or voltage or current sensor. All these components will be fixed on a pole as shown in Figure 1 below. The solar panel is mounted at the top of the pole to minimize the possibility of any shading on the panels.

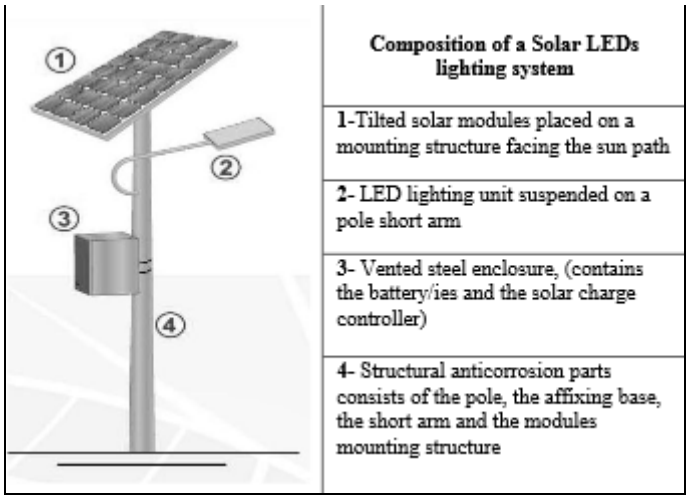


Figure 1: Solar Street Light

2. Description of basic components of solar street light system:

2.1 Solar panel

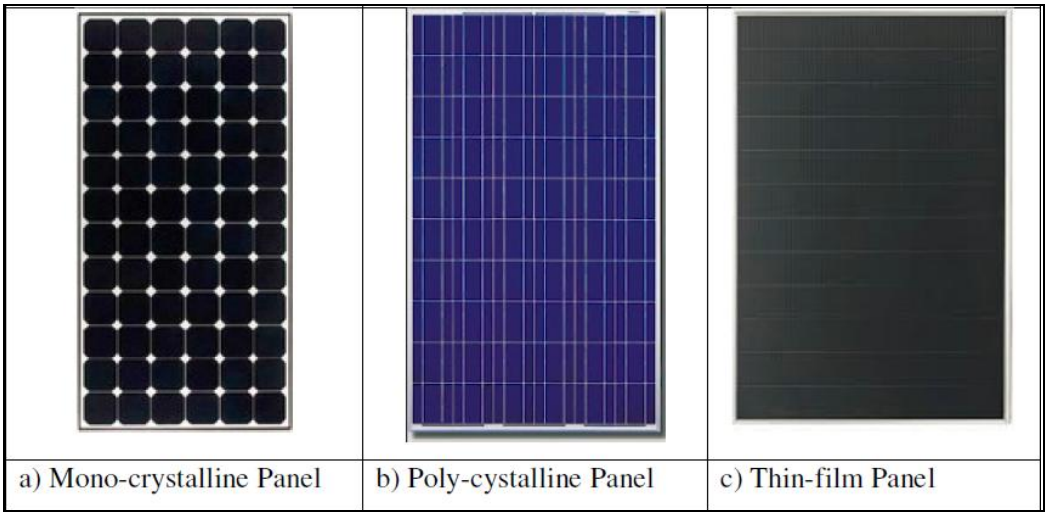
A Solar Panel is basically a module that converts light energy (photons) from the sun to generate electricity in direct current (DC) form. There are two types of solar panels, mainly crystalline and thin-film types.

There are two types of crystalline solar panels (see Figure a & b):

- Poly-crystalline Solar Panel
- Mono-crystalline Solar Panel

As for Thin-film types, there are (see Figure c):

- Amorphous Silicon (a-Si)
- Cadmium Teluride (Cd-Te)
- Copper Indium Gallium Selenide (CIGS)
- Dye-Sensitized Solar Cell (DSC)



a) Mono-crystalline Panel	b) Poly-cystalline Panel	c) Thin-film Panel

Figure 2: Types of Solar PV Module

2.2 Battery

Batteries are used to store the electricity generated by the solar panel. During the day, electricity generated by the solar panels is supplied to the battery and/or the load. When the load demand is higher than the energy received from the solar panels, these batteries will provide stable energy to the load. Solar power applications typically use deep-cycle batteries because they can persist repeated and deep discharges. There are a few types of rechargeable batteries, which are:

(i) Lead-Acid (LA) Battery

These batteries are the most commonly used in solar powered systems due to its maturity in technology and low pricing. They can only be used with low Depth of Discharge (DOD) in order to extend its lifespan. Its DOD ranges from 60%-80%. There are two types of Lead-Acid batteries, i.e. flooded and Valve Regulated Lead Acid (VRLA) batteries which are maintenance free batteries.

(ii) Nickel-Cadmium (Ni-Cad) Battery

Nickel-Cadmium (Ni-Cad) batteries are expensive and disposing of Cadmium is hazardous. Even though they have several advantages over Lead-Acid batteries, such as longer life span, and tolerance for higher discharge, Ni-Cd batteries is not commonly used in solar powered systems due to its high cost and limited availability.

(iii) Lithium-Ion (LI) or Lithium-Polymer (LP) Battery

Lithium based batteries are considered the future of batteries used in solar powered systems. This is due to a number of factors such as high specific energy, high DOD, and higher number of charging cycles. However, due to its higher cost compared to LA type of batteries, they are still not very widely used.

2.3 LED lamp

A LED lamp is a light-emitting diode (LED) product that is assembled into a lamp (or light bulb) for use in lighting fixtures. LED lamps have a lifespan and electrical efficiency that is several times better than incandescent lamps, and significantly better than most fluorescent lamps, with LED able to emit more than 100 lumens per watt.LED are the perfect combinations with solar power as it operates under low voltage, low heat and low power requirement.

Like incandescent lamps and unlike most fluorescent lamps (e.g. tubes and CFL), LED lights come to full brightness without need for a warm-up time; the life of fluorescent lighting is also reduced by frequent switching on and off. Initial cost of LED is usually higher. LED chips need controlled direct current (DC) electrical power; an appropriate power supply is needed. LEDs are adversely affected by high temperature, so LED lamps typically include heat dissipation elements such as heat sinks and cooling fins.

Figure 3: Examples of LED solar street lamps

2.4 Charge controller

Charge controllers are used to control the charging of the batteries. Since the output from solar panels are variable and needs adjustments, charge controllers fetches the variable voltage/current from solar panels, condition it to suit the safety of the batteries. The main functions of charge controllers are to prevent over-charging of batteries from solar panels, over-discharging of batteries to the load and to control the functionalities of the load.

Charge controllers are basically DC-DC converters, where PWM or MPPT technique is used to regulate the switches of the controller. There are three general types of charge controller, mainly:

- Simple ON/OFF Controller
- Pulse Width Modulated (PWM) Controller
- Maximum Power Point Tracking (MPPT) Controller

Most charge controllers operate at three stages to complete the charging cycle of the batteries. These stages vary according to different times and battery voltages. PWM can be employed to control the charging at the stages:

- BULK stage
- ABSORPTION stage
- FLOAT stage

Figure 4: Examples of charge controller

2.5 Utilizing sensors to obtain energy-efficient solar powered street lights

For economical and technical viability, optimized solar powered street lights are obtained using sensors. Sensors such as Ultrasonic sensors, IR Sensors and LDR sensors are used to control the LED lamp functionalities in order to achieve a more energy efficient system. In this case the street light must have auto on and off and must have at least two state of dimming function to save energy, from dusk to dawn.

3. Installation of solar street light system:

The configuration of solar street light system must be designed to be robust and must be good enough to withstand the harsh environmental condition as the system are installed in road where it is continuously exposed to sun, rain, fog, pollution etc. The solar street lighting installation shall not damage aesthetic of the existing city or street plan; rather it shall add beauty to the existing roadway. The solar street lights can be installed in following two ways:

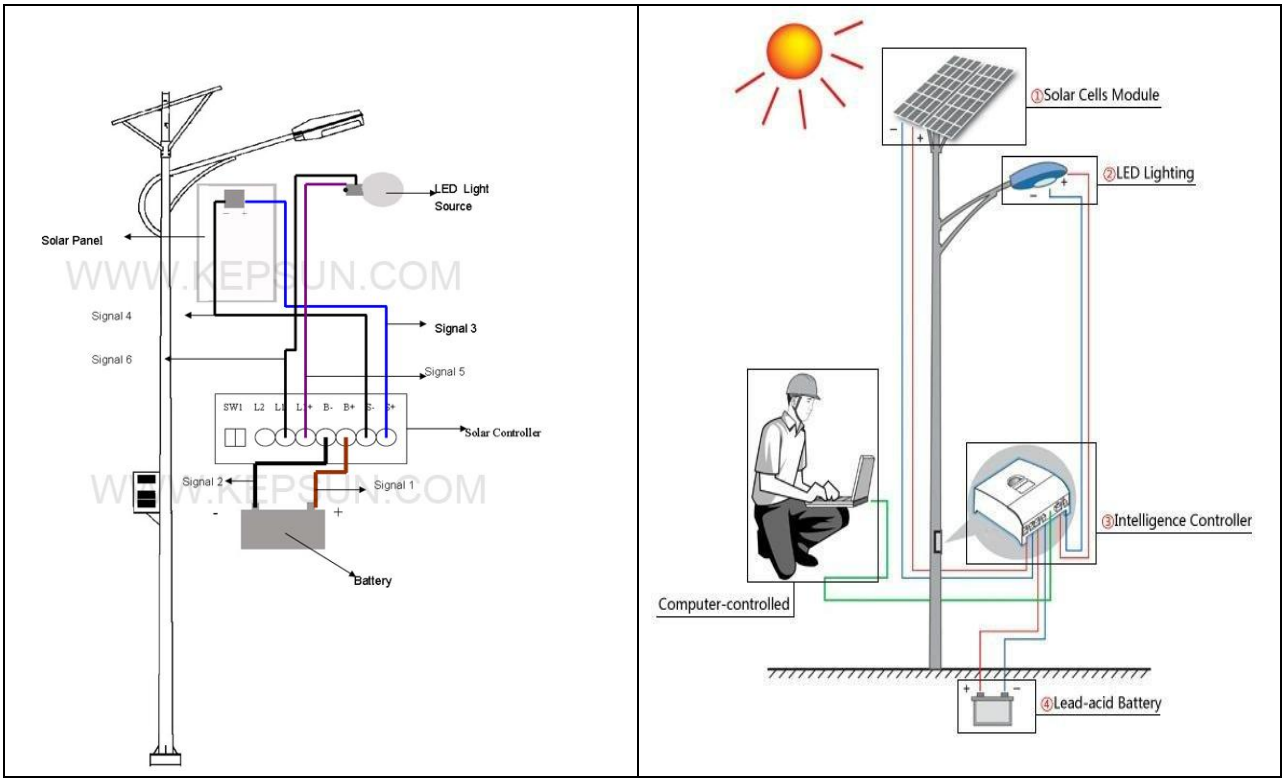


Figure 5: Designs for installation of solar street light

In above figure, first configuration depicts the situation where the battery is kept in the battery box on the pole whereas in second configuration the battery is installed in underground. Either of the configurations can be considered for installation of the system, and it has to be decided case wise case depending upon the requirement of the project site. Nevertheless the battery box mounted on the light pole is common practice in case of stand-alone solar street lighting systems.

2. Defining of packages:

The packages have been defined based on the power consumption of lamps. The package will be selected based on the nature and size of the road for which the solar street light system is being designed.

SSLS Type	Lamp Size (Watt)	Minimum Solar PV Module Size (Wp)	Minimum Battery Size for Lead Acid(AH)	Minimum Battery Size for Lithium Ion (AH)	Minimum Charge Controller Size (A)	Height of pole in meter	Recommended for road having Right of Way (ROW)
Type 1	10	50	40	30	5	7	Less than 4 M
Type 2	20	100	60	45	10	7	4-6 M
Type 3	30	150	80	60	12	7	>6-10 M
Type 4	40	200	100	75	15	8 or 9	>10 -14 M
Type 5	60	300	150	115	25	8 or 9	>14 -20 M
Type 6	80	400	200	150	30	10	>20 – 30 M
Type 7	100	500	250	180	40	10	>30 M

Table 1: Types of Solar Street Light System

3. Technical Specification:

Scope of works shall include:

a. All necessary Spare parts/Tools have to be provided by the contractor.
b. Suitable Carrying case (if possible) should be provided by the contractor.
c. The complete Set of Goods shall be warranted by the contractor against any manufacturing/ design/ installation defects for a minimum period of **5 years** from the date of installation.
d. The contractor will make all necessary arrangements for satisfactory operation, maintenance and performance of the Goods during 5 year's Warrantee/Guarantee period.
e. Rectification of all the defects developed in the Goods during Warrantee/Guarantee period shall have to be done by the contractor promptly, at the most within 7 days from the date of receipt of compliant.
f. Warrantee/Guarantee will include rectification /replacement of all the defective and consumable components/items. During Warrantee/Guarantee period, all the arrangements for keeping all the goods functional shall be the sole responsibility of the contractor.
g. After completion of the proposed works, clearances of all temporary works/ materials shall be the sole responsibility of the contractor and this shall be removed immediate after the requirement of such temporary work is completed.
h. All the non functional parts/ materials/ items replaced during the Warrantee/Guarantee period shall be the property of the contractor.
i. The contractor will conduct on-site training of the purchaser's/user's personnel regarding the assembly, start-up, operation, maintenance and repairs of the Goods.
j. Contractor should have enough experience and qualified technical staff to do design, installation and support. Name, experience certificates and CVs of the engineering staff who will supervise the installation and support should be included.
k. The contractor must nominate in the offer a qualified project manager who should have at least a B.Sc. in electrical/Mechanical/Civil engineering with a minimum experience of 2 years in PV system projects.
l. All works carried-out by the contractor should be maintained and ensure proper functioning of street light for five years starting from the date of final acceptance.
m. The Contractor will be responsible for all engineering and design.
n. The contractor will be responsible for cleaning of the solar PV module for at least five years from the date of installation and commissioning.

Technical Specifications:

The bidder must furnish documentary evidence in the form of literature (catalogue), certified dimensional drawings, and detailed description of goods with essential technical information. All data, drawings, catalogues and other technical documents shall be bound separately from the Bid documents.

The Bidder shall furnish a clause-by-clause commentary on specification, specifying compliance and deviations, if any. This must be furnished; otherwise, the Bid may be rejected.

1. BATTERY

SN	Description	Specification
1.1	Manufacturer Name	
1.2	Brand/Model	
1.3	Battery Type	Lead Acid Sealed- Gel Tubular VRLA solar deep cycle or Lithium ion with proper protection
1.4	Battery Voltage	For Lead Acid battery: 12V For Lithium Ion battery the bidder must propose the voltage compatible to system
1.5	Battery Efficiency	Minimum 85%
1.6	Quantity (mention capacity)	Individual battery must be of at least……. *(Capacity must be selected as per the type of solar street light mentioned in table 1)*
1.7	Pressure Regulation	The battery shall be provided with pressure regulation valve, which shall be self-re-sealable and flame retardant
1.8	Self Discharge	less than 3% per month
1.9	Operating Temperature	-5 °C to 55°C
1.10	Instruction	Charging instructions shall be provided along with the batteries
1.11	Warranty	5 years replacement guarantee.

1.12	Construction	**For Lead Acid Battery:** **Positive Plate:** Tubular Plate with lead or alloy spine grid. **Separator:** Micro porous synthetic separator **Electrolyte:** Sulphuric acid. **VRLA Terminals:** Epoxy sealed terminals with threaded lead-plated copper alloy
1.13	Battery Life Cycle	At least 1500 at 80% DoD
1.14	Certification	RETS Certified

The following minimum information must be included on the label of the battery and label of battery must be fixed firmly or screen printed on the battery casing:

- Brand and name of Manufacturer
- Model and type
- Rated capacity in Ampere-hours
- Nominal Voltage

2. Solar PV MODULES

Solar PV Modules will be procured from companies, complying with the standard set forth in Nepal by AEPC. PV modules shall typically be tested for durability and reliability according to standards developed by the International Electro-technical Commission. Standards IEC61215 (for crystalline silicon modules) include, amongst others, tests for thermal cycling, humidity and freezing, mechanical stress and twist, hail resistance and performance under fixed test conditions.

SN	Description	Specification
2.1	Manufacturer Name	
2.2	Brand/Model	
2.3	Module Capacity	Minimum Module Capacity must be……*(Capacity must be selected as per the type of solar street light mentioned in table 1)*
2.4	PV module Type	Mono or Poly Crystalline or Thin Film

2.5	Operating voltage corresponding to the power output (Vmp)	At least 34 Vmp for each module of 24V and 17 Vmp for each module of 12 V for crystalline For thin film the Vmp of the module must be at least 40% higher than the system voltage
2.6	Minimum Module efficiency at STC:	Crystalline: Minimum 14% Thin Film: Minimum 10%
2.7	Power degradation	A letter provided by principal PV module manufacturer in their letter head stating the warranty period for their PV module. The warranty period for the PV Module must be at least 10 years against a maximum 10% reduction and 20 years against a maximum 20% reduction of output power at STC.
2.8	Junction Box	IP 65 or above
2.9	Module Mounted Structure	Non corrosive support structures to be fixed on the top of pole. For areas where there is problem of shading in some of the site of installation, the solar PV module of that particular solar street light system can be installed at rooftop of nearby house. An agreement has to be signed between the user community and the owner of the house for such installations.
2.10	Tilt Angle and direction	towards due south around local latitude
2.11	Support structure design and foundation mounting arrangements should withstand	Wind Speed up to 180 km/hr
2.12	Fasteners (nuts and bolts)	Stainless Steel or hot deep galvanized.
2.13	IEC 61215 (2nd Edition) IEC 61646	Crystalline silicon terrestrial photovoltaic (PV) modules - Design Qualification and type approval. Thin-film Terrestrial Photovoltaic (PV) Modules-Design Qualification and Type Approval
2.14	IEC 61730	PV module safety qualification

2.15	Certifications	RETS Certified

3. Charge Controller

SN	Description	Specification
3.1	Manufacturer Name	
3.2	Brand/Model	
3.3	Type	Solar Charge Controller or Regulator
3.4	Control Mode	For Type 1, 2 & 3- PWM or MPPT For Type 4, 5, 6 & 7 – MPPT will be preferred With Dusk to Dawn i.e., the lamp automatically switches ON after the sunset and switches OFF after sunrise. Also include at least two stage of dimming function. First stage-system should function at 100% load for six hours and second stage: system should function at 50% load for next 6 hours (with reduced illumination).
3.5	Working Temperature & Humidity	-5 to +55 °C/35 to 85%RH (Without Condensation)
3.6	Protection Function	Solar reverse-charging protection, solar reverse-connection protection, battery over charge protection, battery over-discharge protection, battery reverse-connection protection
3.7	Size	The capacity of charge controller must be ……*(Capacity must be selected as per the type of solar street light mentioned in table 1)*
3.8	Certifications	RETS Certified

4. Solar Street Light or Lamp Set

SN	Description	Specification
4.1	Manufacturer Name	
4.2	Brand/Model	
4.3	Type	Light Emitting Diode (LED)
4.4	LED Light Source	The capacity of light must be ……*(Capacity must be selected as per the type of solar street light mentioned in table 1)*
4.5	Luminous Efficacy	At least 100 Lumen/watt
4.6	LED Illumination	Street lamp should have illumination not less than 0.5 Lux/Watt perpendiculars from the height of 9 m. The illumination should be uniform without dark rashes on the ground.
4.7	View Angle	Equal or greater than 2 * 50
4.8	Color Rendering Index (CRI)	CRI of Individual WLED must not be less than 60 and the color temperature must be in the range of (5000-6000)°K
4.9	Lamp Rated Total Power	The capacity of light must be ……*(Capacity must be selected as per the type of solar street light mentioned in table 1)*
4.10	Control Function	Must have Automatic dusk to dawn function. Also include at least two stage of dimming function. First stage-system should function at 100% load for six hours and second stage: system should function at 50% load for next 6 hours.
4.11	Driver Circuit	Must have Driver circuit cum Charge Controller with not less than 85% efficiency.
4.12	Protection	The lamp must be protected against reverse polarity
4.13	Certification	Must submit IP65 or above Compliance Certificate
4.14	Expected Life:	The proposed LED life shall be minimum 50,000 hours
4.16	Certifications	RETS Certified

The following minimum information must be included in the screen printed label of the LED Street lamp

a. Brand/Model/Serial number
b. Nominal power in Watt
c. Nominal voltage

5. Street Light Pole

SN	Description	Specification
5.1	Manufacturer Name	
5.2	Type	Hot Deep Galvanized (minimum coating 80 micron?)
5.3	Height	The minimum height of the pole must be ……*(height must be selected as per the type of solar street light mentioned in table 1)*
5.4	Thickness of Pole	**For 10 meter pole:** Top 2.4 meter: 3.65 mm Middle 2.4 meter: 4.5 mm Bottom 5.2 meter: 4.5 mm **For 9 meter pole:** Top 2.0 meter: 3.25 mm Middle 2.0 meter: 4.5 mm Bottom 5.0 meter: 4.85 mm **For 8 meter pole:** Top 1.75 meter: 3.25 mm Middle 1.75 meter: 4.85 mm Bottom 4.5 meter: 5.4 mm **For 7 meter pole:** Top 2.5 meter: 3 mm Bottom 4.5 meter: 4 mm

	Diameter of Pole Sections	**For 10 meter pole:** Top 2.4 meter: At least 3 inch Middle 2.4 meter: At least 4 inch Bottom 5.2 meter: At least 5 inch **For 9 meter pole:** Top 2 meter: At least 3 inch Middle 2 meter: At least 4 inch Bottom 5 meter: At least 5 inch **For 8 meter pole:** Top 1.75 meter: At least 3 inch Middle 1.75 meter: At least 4 inch Bottom 4.5 meter: At least 5 inch **For 7 meter pole:** Top 2.5 meter: At least 3 inch Bottom 4.5 meter: At least 4 inch
5.5	Arm	Single arm or double arm depending upon site condition and lighting area coverage
5.6	Weight of pole only	**For 10 meter pole:** At least 150 Kg **For 9 meter pole:** At least 120 Kg **For 8 meter pole:** At least 95 Kg **For 7 meter pole:** At least 75 Kg
5.7	Battery box	A vented, acid proof and corrosion resistant metallic box with a locking arrangement for outdoor use should be provided for housing the battery.

5. Civil Works

The civil works for the proposed Solar Street Lighting System shall include Solar Street Light pole design and installation at the site. The structure should be facing south direction tilted at 30 degree. Pole and Mounting structure must be designed accordingly. It should be able to withstand wind loading of 180Km/hr and support the installed solar modules.

- Bidder must provide the technical design and drawing of the SSL Pole.
- Bidder must provide evidence and calculation showing the structure proposed is safe to be put on the top of pole.

6. **Operation and Maintenance Manual**

An Operation, Instruction and Maintenance Manual, in English and the local language, should be provided with the Solar Street Lighting System and detail of Wiring and Connection Diagrams shall also be provided with the manual.

7. Warrantee/ Guarantee

(i) The Solar Street Lighting System must be warranted against any manufacturing/ design/ installation defects and performance warranty for a minimum period of 5 years.

(ii) PV modules used in the solar street lighting system must be warranted for their rated output

(iii) The Warrantee/ Guarantee Card to be supplied with the SSL System must contain the details of the system supplied. The manufacturers can provide additional information about the system.

(iv) During the Warrantee/ Guarantee period, purchaser will have all the rights to cross check the performance of SSL System. Purchaser may carry out the frequent inspections of the system installed and randomly pick up its components to get them tested at any test center. If during such tests any part is not found as per the specified technical parameters, Purchaser will take the necessary action. The decision of Purchaser in this regard will be final and binding to the Bidder.

Safety:

1. Metal parts of Solar Street Lighting System must be provided with minimum clearance of 1.25 meter from NEA 400V/11 KV distribution line.
2. Proper installation safety like insulating gloves, safety belt, helmets etc.
3. The metal item items such as watches, rings and necklaces are all good conductor of electricity and should not be worn around the electrical components.
4. Manufacturer instructions shall be followed by the operator for safe operation of solar electrical technology.

Prerequisite for proper functioning of Solar Street Light project:

1. Solar PV Module must be cleaned regularly between two to three weeks period depending upon the urban dust.
2. It is recommended to do cleaning and greasing of Battery terminal in quarterly basis.

Retrofitting in Existing NEA Pole:

In the areas where there is no sufficient space for new solar street lights to be installed, existing NEA pole can be used for installation of solar street lights. In this type of system, existing pole of NEA will be used for installation of solar panel, battery with battery box and street lamps.

Centralized Solar Street Lighting System:

For the roads that do not have enough shadow free areas, standalone solar street lighting system is not recommended and only centralized solar PV system is strongly recommended. To this type of street lighting scheme, site specific detail technical survey and design has to be carried out. The centralized system power output shall be of AC power and therefore the selected LED lamp must be of AC type. In centralized system, arrays of PV panels will be fixed at a convenient location and the power output from the source is distributed to the lights in a particular group via distribution cables. For this type of lighting system, since the battery will be installed at one place as one battery bank, use of flooded tubular deep cycle battery in addition to the battery type mentioned above (Gel Tubular and LI Ion) can also be used.

Reference:

1. A COST EFFECTIVE SOLAR POWERED LED STREET LIGHT, By FREDERICK WONG TSUN KIONG
2. Product diagrams and line diagrams from various websites.

Annex:

Reference cost estimation model:

S.N.	*Name of the component*	*Technical Specification*	*Quantity*	*Cost (NPR)*	*Remarks*
1	Solar PV Panel	140 Wp	1	14,000	Non VAT Item
2	Battery (12 v)	100 Ah Tubular Gel @C10	1	28,000	Non VAT Item
3	Charge Controller With Dusk to Down Function, three stage dimming function	Size as required by panel	1	3,500	Non VAT Item
4	Lamp (LED)	40 Watt	1	12,000	Non VAT Item
5	Single Arm Galvanized Pole	9 m	1	27,120	Vatable Item
6	Interconnecting Wires & Other Accessories (Nut-Bolt, Earthing)			1700	Vatable Item
7	Installation/ Transportation Charge			10000	Vatable Item
8	After Sales Service			5000	Vatable Item
		Total Cost including VAT		**101,320**	

Note: The above table is model for cost estimation of the typical complete solar street light system for bidding purpose. The system proposed in the cost estimation table does not exactly match with any of the seven different types proposed in this document in Table 1.